Exposing freely moving homing pigeons to varying magnetic fields activates neurons in the olfactory bulb and olfactory cortex

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Homing pigeons and many other birds sense geomagnetic fields and probably use it for navigation. Magnetic stimulation does activate neurons in various brain structures linked to visual and vestibular input, and integrating brain regions. Yet, natural or artificial disturbance of the earth magnetic field is often compensated in pigeons and seabirds, while permanently blocking olfactory input impairs homing of pigeons drastically. The same is observed after lesions of the piriform (olfactory) cortex (CPI), to which recent studies attribute a multimodal associative role. If so, one might expect neurons in the CPI to respond to magnetic stimulation, and, because of CPI efferent axons to the olfactory bulb, possibly, in this structure also. We have exposed homing pigeons moving freely in a box to either magnetic fields varying periodically at 0.55 Hz between 16 and 187 !Tesla at the pigeon's head, or to sham stimulation, and counted stereologically neurons expressing the immediate early gene ZENK, a marker of neuronal activity. Magnetic stimulation induced a highly significant bilateral increase of ZENK-expressing neurons in the olfactory bulb (+40%), the piriform (olfactory) cortex (+64%), the hippocampus (+46%), the nidopallium caudolaterale (+27%), and in hyperpallial nuclei and the mesopallium (+14%). No increase was observed in the wulst (hyperpallium apicale), in posterodorsal thalamic nuclei, and in amygdaloid nuclei; a significant decrease occurred in vestibular nuclei (-18%).

At present it is not clear whether the pigeon olfactory system can sense magnetic field information directly, or whether it receives input from other magnetosensitive structures. Regardless of this, our study implies an essential integrating role of the olfactory system for pigeon navigation, and calls for further investigation of concomitant processing of olfactory and magnetic information.